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MAPPING OF PERIODIC FURNACES LINED WITH REFRACTORY FIBER

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Methods for measuring temperature and gas gradients in periodic furnaces in a series of Gzhel' enterprises producing artistic porcelain are examined. It is noted that the author's method for mapping periodic furnaces makes it possible to determine the temperature and gas gradients in the charge volume of furnaces. Samples of porcelain paste, colored with iron and manganese, and temperature monitoring rings were used. It is recommended that ALSITHERM refractory fiber be use for lining in order to obtain a more uniform temperature distribution in the working zone.

Key words: periodic-action furnaces, temperatures and gas gradients, mapping, refractory fiber.

The experience gained from many year of operating periodic furnaces (PFs) whose purpose is to fire porcelain shows that temperature and gas gradients exist over the charge volume of a furnace, and affect the quality of the ready articles and the firing time. The temperature and gas gradients in furnaces are due to numerous factors: structural imperfections, imprecise regulation of the burners, use of high heat-capacity refractory materials during furnace assembly and operation, as well as nonconformance to the modern requirements of instruments for monitoring and regulating the state of the gas inside a furnace. Temperature differentials and the firing time depend directly on the live section of the working zone of a furnace. The larger the useful cross section of a furnace and the higher the charge, the larger the temperature differentials over the height of the charge, the longer the cycle, and lower the firing quality are [1].

In a number of enterprises in Gzhel' [2, 3], a rapid method was proposed for monitoring the structure of the fired ceramic which made it possible to determine the presence of a temperature differential and heterogeneity of the gas medium by means of EPR-NMR spectroscopy and precision magnetic measurements.

Rapid analysis of the structure of fired porcelain samples showed that in PFs there arise substantial high-gradient regions between the bottom and top of the charge, and in addition there are so-called dead zones where the gas composition is nonuniform — either weakly reducing or oxidative, which was characterized by the color and structural nonuniformity of the porcelain samples.

The temperature nonuniformity was especially large at the door of a PF and at the top of trolleys. On the whole the method used made it possible, to a certain extent, to adjust the temperature and gas regimes of glost firing in order to improve the quality of the porcelain decorated with cobalt subglaze paints.

Since the temperature during firing of porcelain was monitored by fusion cones (FCs) and thermocouples, which had a definite error, and the composition of the gas medium was quite difficult to monitor instrumentally because of a lack of stationary sensors for analyzing the gas inside the furnace, it was impossible to eliminate the temperature and gas gradients completely.

Attempts to upgrade PFs to decrease their energy intensiveness and the temperature gradient and to eliminate dead temperature and gas zones were undertaken at the Gzhel' plant "Élektroizolyator." To construct a new 18 m^3 PF, 10 burners were mounted in a checkerboard order between the charge of the trolleys with oppositely moving combustion products; this presupposed more uniform heating of the charge as a result of the arrangement of the burners, better construction of the burners, and a decrease of the dead temperature and gas zones inside the furnace.

Modern heat-insulating materials — ALSITHERM refractory fiber matting — were used to line the interior of a

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furnace — the roof and doors, i.e., locations where substantial temperature gradients were observed in PFs with similar construction.

In the course of the setup procedures and adjustment of the temperature and gas-dynamic regimes of glost firing, the present authors proposed a new complex procedure for mapping a furnace using tiles made of porcelain paste colored with iron and manganese oxides (5.0 – 6.0 Fe_2O_3 and 1.4 – 2.0% MnO_2 above the 100 wt.% content), ceramic temperature-monitoring rings (CTMRs).

Using this method 12 samples of 50 × 50 mm tiles made of colored paste, CTMR, FCs 132, 135 were arranged on the shelves of four trolleys from bottom to top in a manner so that the temperature and gas gradients could be checked in the volume of the charge: top to bottom, along the diagonal, and in the intercharge spaces (combustion zones) by visual color assessment of the state of the tiles, the size of the CTMR, and drop of the cones. In the course of the glost firing the temperature in the furnace was monitored simultaneously point by point using platinum thermocouples and the gas medium by means of a portable gas analyzer.

The analysis of the results obtained by mapping two 18 m^3 furnaces showed that the highest temperature 1352 – 1371°C in the furnaces was observed in the top shelves of the trolleys, i.e., in the space below the roof, at the furnace doors, and in the burner zones. This was indicated by the characteristic swelling of the samples, decrease of the CTMR size, and drop of the FCs 123, 135. The largest temperature difference along the transverse cross section of the charge was 23°C and the diagonal difference was 27°C. For lower temperatures 1336 – 1345°C, mainly at the center of the furnace charge, no swelling of the samples was observed, which was confirmed by the more uniform firing and good quality ready porcelain articles on the basis of their visual assessment during sorting. The swelling of the colored paste in the temperature range 1352 – 1371°C was apparently due to the separation of the iron and manganese oxides at these temperatures, release of gaseous substances in this temperature interval, and formation of low-melting eutectics. The color of the samples indicated a heterogeneous composition of the gas medium over the volume of the charge. In a large volume of furnace charge (approximately 80% of the volume of all trolleys), a one-tone light-brown color of the samples was observed due to the coloring by iron and manganese oxides of porcelain fired samples in a uniform gas medium. In part of the top shelves of the trolleys, the color of the samples was dark with a manganese tinge, which indirectly confirmed the nonuniformity of the gas medium at the final stage of firing — reduction soaking in this part of the furnaces.

In summary, using the proposed method, the temperature and gas regimes of glost firing in two PFs were adjusted after comparing the sizes of the CTMRs, the color of the colored samples with thermocouple indications, and the character of the drop of the FCs and evaluating the chromaticity of the ready porcelain at the mapping locations of the furnace charge. It should be noted that partial lining of the furnace (roof and door) with a refractory fiber led to an increase of the temperature in these parts of the furnace. Here a higher temperature was observed on the shelves of trolleys relative to the entire charge. Therefore, a furnace must be lined completely with a refractory fiber in order to attain a more uniform temperature distribution in the furnace and, therefore, to increase the quality of the fired articles.

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